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FIRST RESULTS OBTAINED BY THE AMD-BA COMPANY FROM  
THE ROTARY ASSEMBLY OF THE IMF LILLE

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16. Abstract  <b>Much effort has been made over the past few years to extend the flight range of combat airplanes to high incidences. This penetration into the nonlinear range makes it more difficult to forecast flight qualities. Our company is interested in acquiring a rotary assembly like the one manufactured by the IMFL for the incompressible range. The present report will discuss the results obtained on a modern combat airplane with delta wings. Even though only part of the program has been carried out, it is possible to draw the first conclusions from this operational rotative assembly.</b>			
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# ABSTRACT

Vigorous efforts have been made over the past few years to extend the flight range of combat airplanes to high incidences.

This penetration into the nonlinear range makes it more difficult to forecast flight qualities.

This is why our company is interested in acquiring a rotary assembly like the one manufactured by the IMFL for the incompressible range.

The present report will discuss the static and dynamic results obtained on a modern combat airplane with delta wings.

Only part of the over-all program has been executed until now.

It is nevertheless possible to draw the first conclusions from this mechanical flight assembly which is now operational.

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FIRST RESULTS OBTAINED BY THE AMD-BA COMPANY  
FROM THE ROTARY ASSEMBLY OF THE IMF LILLE

C. Couedor

The purpose of this short report is to present the results of the industrial claimant and first user.

The report will first provide a summary of a few concepts which are indispensable for understanding the contents. They were developed in a preliminary phase by the IMFL.

1 - INTRODUCTION

The aircraft manufacturer does not have the appropriate means at his disposal to evaluate flight qualities under extreme conditions of incidence and side-slip associated with motions of large amplitude.

This handicap becomes more troublesome when flight ranges are extended, especially in the case of military airplanes.

Until recently, the means of analysis were still limited to measuring stationary or dynamic characteristics of small amplitudes in the windtunnel. They were applied to the operation of free remote controlled models dropped in the air or tested in the laboratory.

There has been a strong interest in developing windtunnel tests capable of simulating both large angles of attack and motions.

During the first half of 1976, the AMD-BA and the IMFL joined efforts in a rotative balance project financed by the "General Studies" section of the STAé.

2 - SUMMARY DESCRIPTION OF THE INSTALLATION

This report will not discuss the extension "spins", which was not included in the initial AMD-BA proposal.

Plate no. 1 shows that the sting type assembly is used in the IMFL windtunnel for spins with the SV4 open jet section ( $\phi$  4 m,  $V_{max} \approx 40$  m/s).

The capabilities used for time are defined as follows:

-Inclinable rotation axis of  $\lambda$  on the speed vector.

The controlled rotation speed  $\omega$  reaches  $600^\circ/\text{s}$  in both directions. The angular situation of the model is characterized by angle  $\psi$ .

-The angle of the model axis with the rotation axis  $\theta_2$  is between  $0$  and  $45^\circ$ .

-Lateral attitude  $\varphi$  is between  $\pm 180^\circ$ .

These different operations are controlled remotely and by position transducers. The balance signals, particularly, are obtained by a rotary collector.

Plate no. 2 illustrates the area ( $\alpha, \beta$ ) covered during a test when  $\lambda, \theta_2, \varphi$  are given.

### 3 - MODEL/BALANCE ASSEMBLY

The 1/8.6 scale model used for the low speed tests of the MIRAGE 2000 is used for the model/balance assembly. See plate no. 3.

The light alloy structure with plastic skin does not have any special weight problem. It weighs 37 kg, the air inlets are streamlined and the leading edges are projected.

Reference surface =  $0.554 \text{ m}^2$

Fuselage length =  $1.667 \text{ m}$

The 5 component dynamometer (without drag) is borrowed from the

AMD-BA balance park.

The nonspecific characteristic of these two components was assumed in a first phase devoted to breaking the system in.

#### 4 - COLLECTION, PROCESSING OF SIGNALS

The 360° of one rotation are divided into 128 "intervals". A mean value of the aerodynamic coefficients is assigned to each interval.

The sampling frequency may be adjusted up to 130 kbits. Under these conditions, the collection frequency per channel is 678 Hz, sub-cycling included.

The measuring device is equipped with a set of analog filters  $f_c \approx 110$  Hz, with attenuation of 14 db/octave. The structural frequencies of the assembly were between 11 and 21 Hz. It was therefore necessary to use an auxiliary digital low-pass filter of 10 Hz.

#### 5 - STATIONARY RESULTS

Due to the placement of a bulky assembly in the test section, the operation began by improving the aerodynamic characteristics; they were then identified accurately (modulus and direction of the speed vector in the space scanned by the model).

The following investigations were devoted to checking the longitudinal and lateral aerodynamic characteristics of the model.

Plates no. 4 to 7 show that by correcting  $\alpha$  and  $\beta$ , which were predetermined, it is possible to make comparisons with the assembly of other windtunnels used, at least for the approximation of the maximum  $C_z$ .

The loss of maximum lift ( $\Delta 100 C_z = 10$ ), accompanied by a sudden



variation in the lateral parameters) is due to the premature outburst of the vortex lift under the positive static pressure gradient remaining in the test section.

Losses of this type were noticed in another laboratory on an assembly with precisely the same gradient.

This is why an immediate campaign was conducted in February 1979 on a model two times smaller, with a scale of 1/15, designed for high speed tests. See plate no. 8.

The only purpose was to determine if the appearance of the maximum lift was corrected by increasing the distance relative to the supports (slope  $\frac{dp_s}{d\pi}$  increased substantially near the rear).

This is the case in plate no. 9.

#### Duplicability of the Static Tests

It is well identified in the longitudinal range. It may be evaluated with widely spaced cross-checks without operation on the model:

$$\begin{aligned}\Delta 100 C_z &= \pm 0.75 \\ \Delta 100 C_m &= \pm 0.075\end{aligned}$$

#### 6 - FIRST UNSTATIONARY RESULTS

Plates no. 10 and 11 are taken from the first operational campaign of March 1979. One hundred tests were carried out for the following range:

$$\begin{aligned}- 20 < \alpha^\circ < 30 \\ - 20 < \beta^\circ < 22 \\ \omega &\leq 600^\circ/\text{s}\end{aligned}$$

see pl. no. 12

The AMD-BA treatment which led to the high incidence model is still not established.

Based on the initial form of the results requested at the IMFL, it is still not possible to define the quality of the results, namely:

Pure Duplicability Differences between tests with $\frac{W}{V}$	$\pm 100 \Delta C_y$	$\pm 100 \Delta C_z$	$\pm 100 \Delta C_L$	$\pm 100 \Delta C_M$	$\pm 100 \Delta C_N$
	0.5	1.5	0.15	0.1	0.2
22.9 < V * < 40 m/s	0.6	1.5	0.25	0.15	0.2

\*windtunnel

## 7 - CONCLUSION

An operational rotative assembly is now available to aircraft manufacturers at the SV4 IMFL.

It is easy to see that the IMFL and manufacturing references may be improved as a function of the problems which are found.

It seems, however, that the fuselage lengths should be limited to about one meter. This does not affect reduced rotation speeds in the case of a delta wing, provided that it is possible to operate at a reduced windtunnel speed.

The AMD-BA is concentrating on light models taken directly from the high speed die-plate and equipped with adjusted balances.

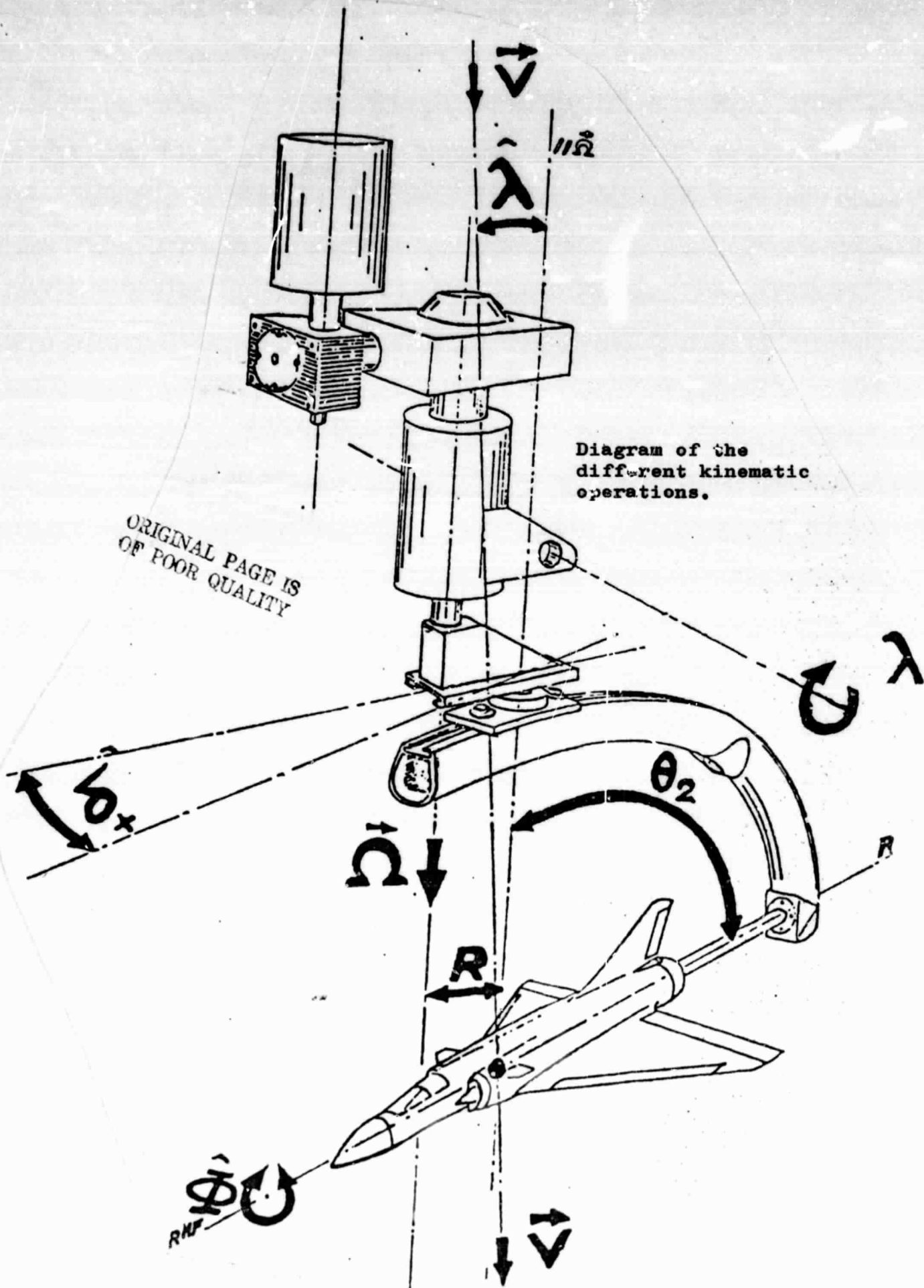


Plate 1

Simplified illustration of the area  $(\alpha, \beta)$   
covered by using predetermined

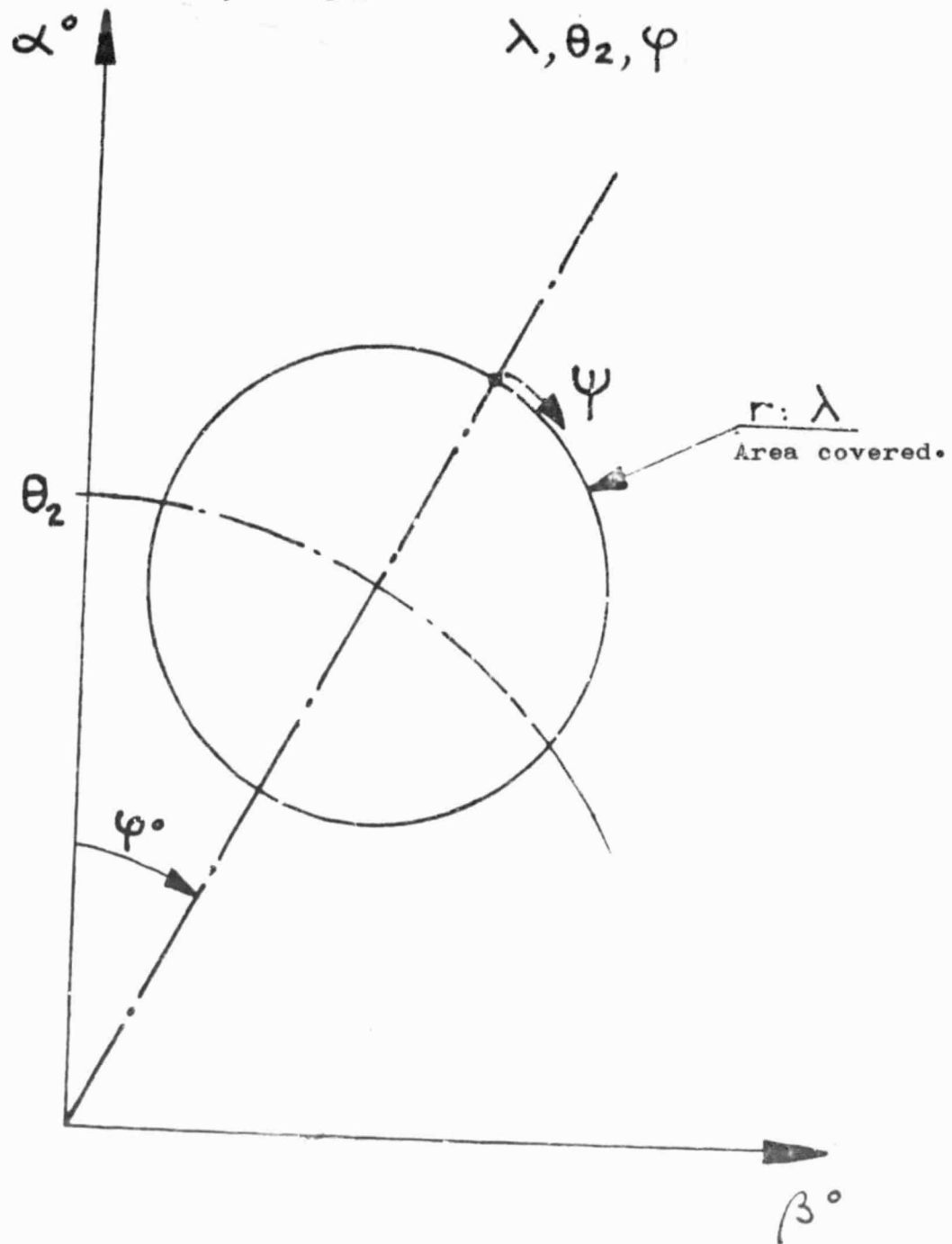
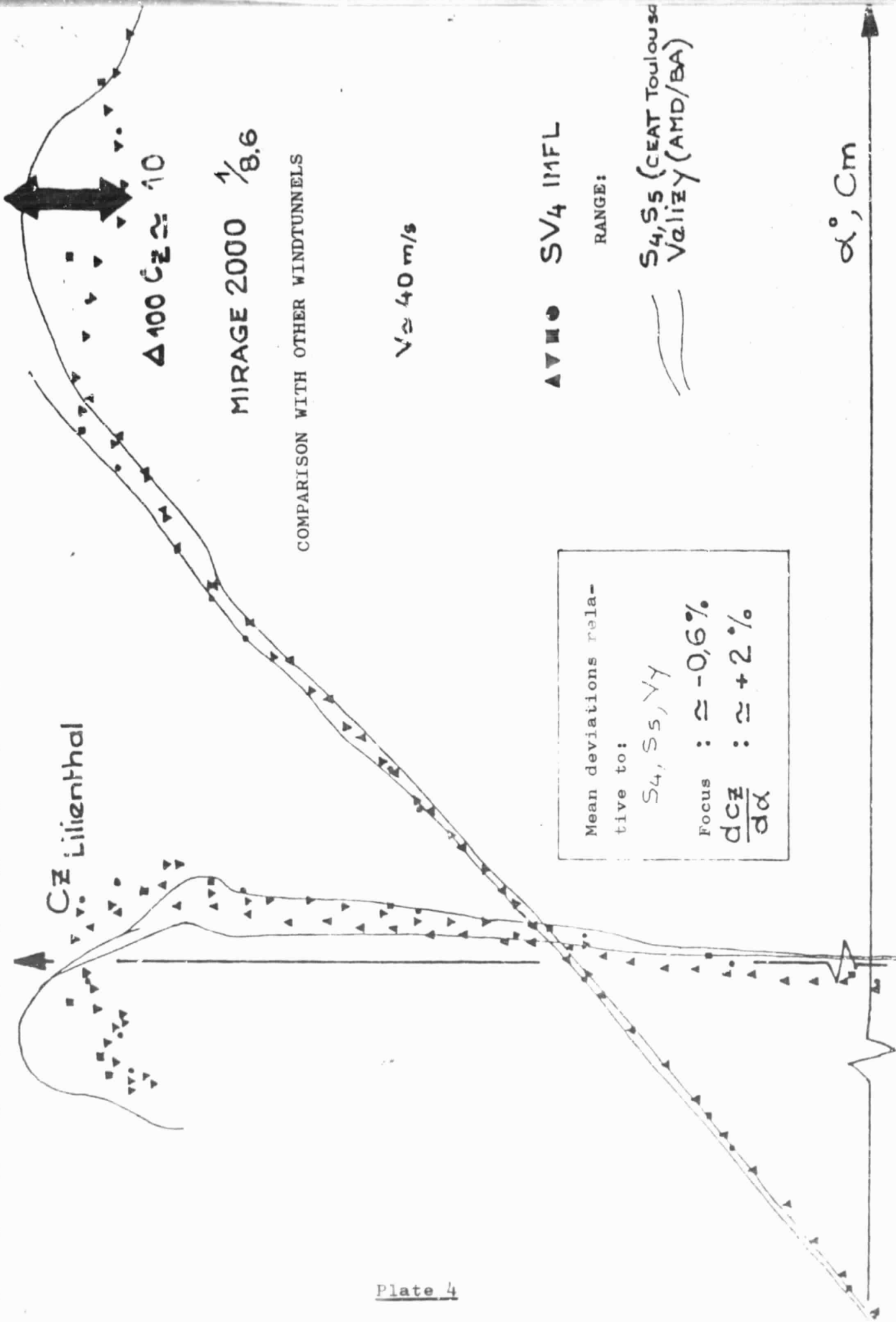


Plate 2



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OF POOR QUALITY

Plate 3



CZ Lilienthal

MIRAGE 2000  $1/8.6$ 

DUPLICABILITY WITH THE IMFL SV4

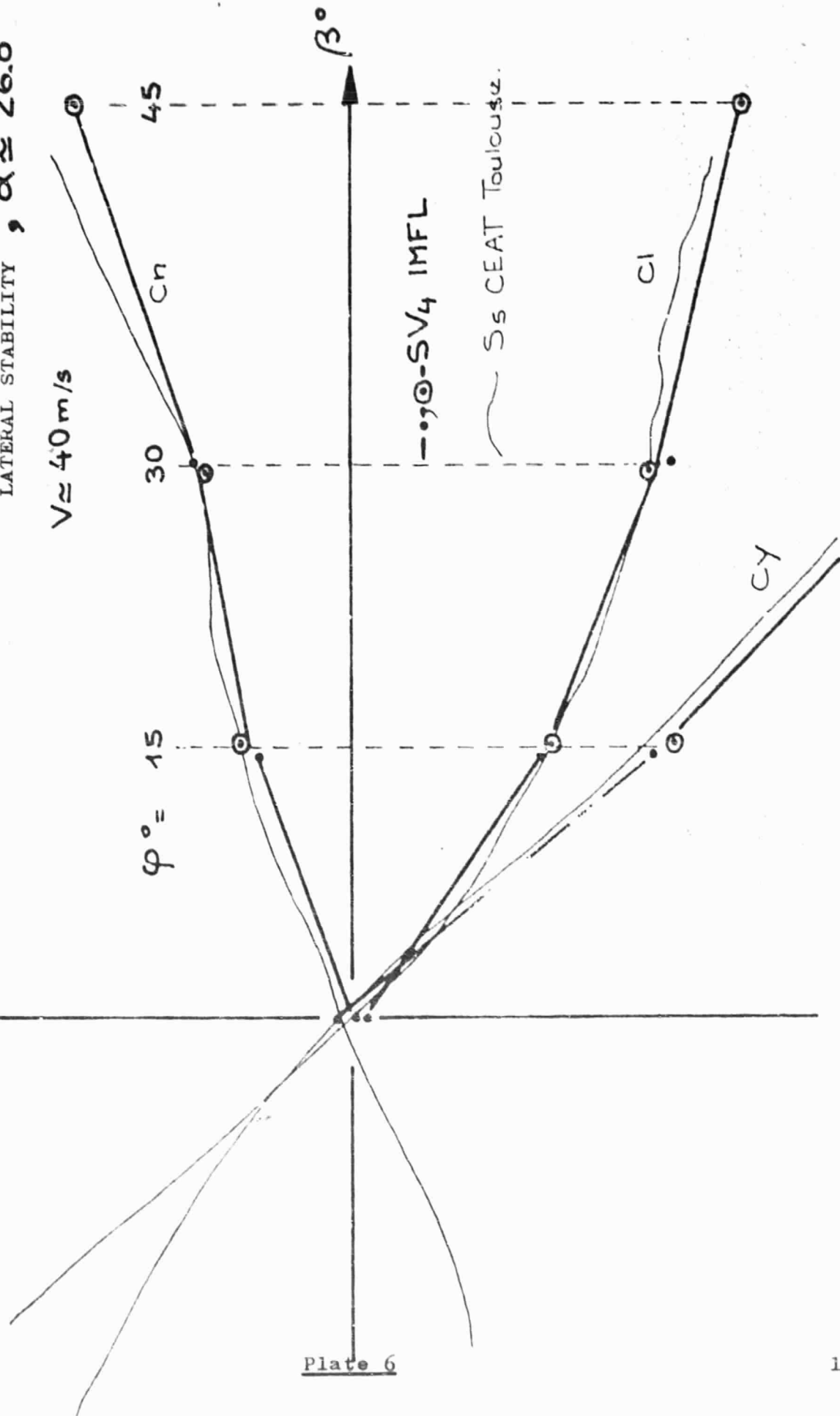
 $V_c = 40 \text{ m/s}$ 
 $\Delta 100Cz = \pm 0.75$   
 $\Delta 100Cm = \pm 0.075$ 
ORIGINAL PAGE IS  
OF POOR QUALITY $\alpha^\circ, \text{Cm}$

$\Delta C_l, C_n, C_y$  Lilienthal

MIRAGE 2000  $\frac{1}{8.6}$

LATERAL STABILITY,  $\alpha \approx 26.8^\circ$

$V \approx 40 \text{ m/s}$





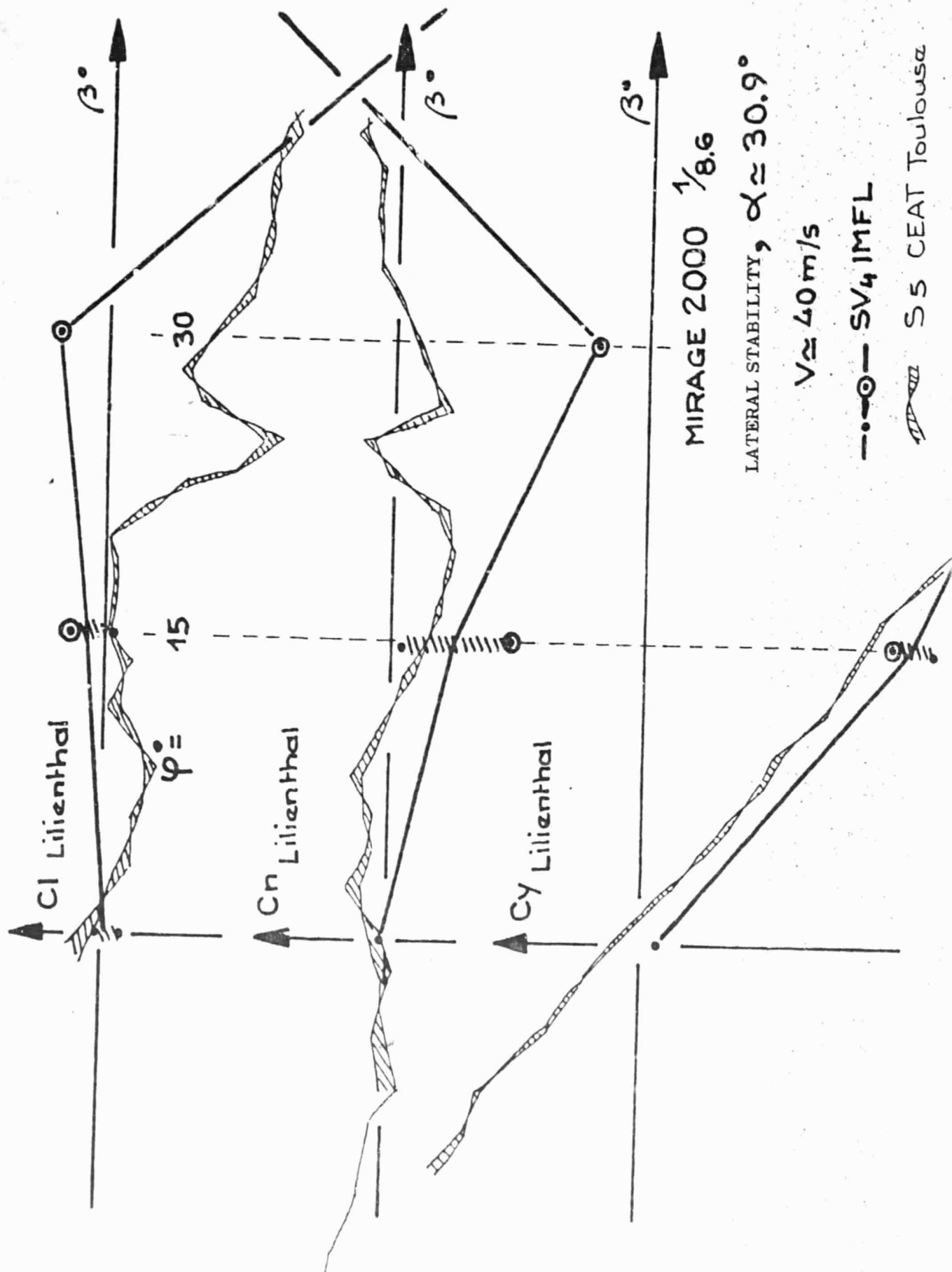


Plate 7



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CZ Lilienthal

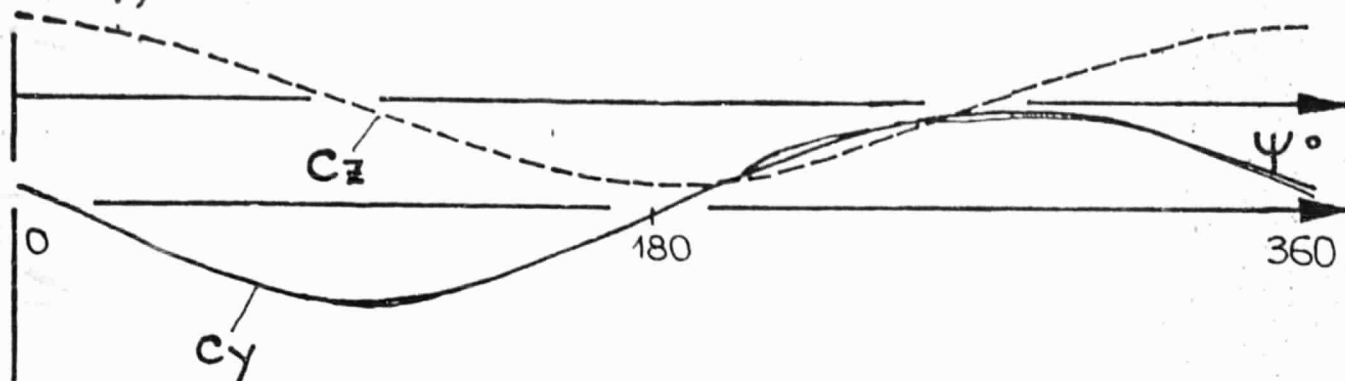
MIRAGE 2000

COMPARISON WITH SCALE 1/13

▲VHO SV4 IMFL, 40m/s

— S2 Modana ONERA,  $M=0.3$  $\alpha^\circ$ , Cm

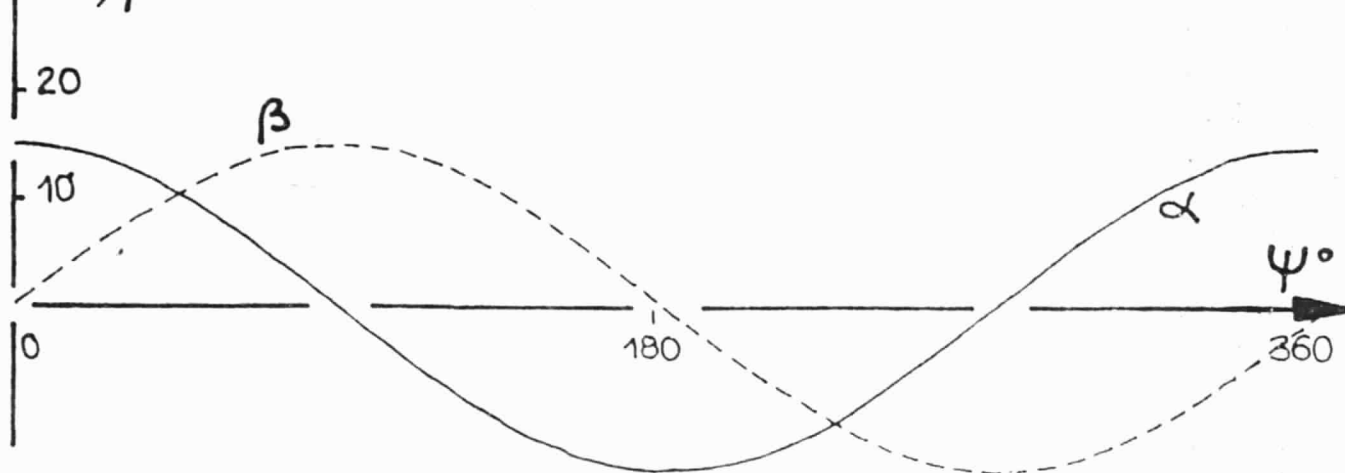
$C_Y, C_Z$  Lilienthal



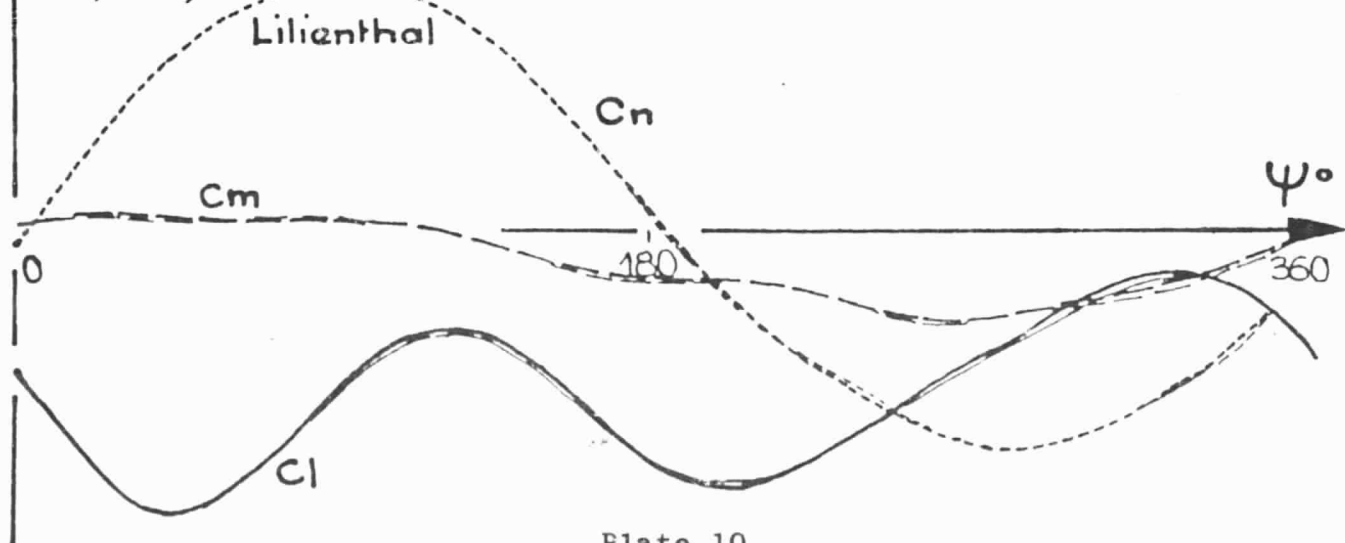
MIRAGE 2000  $\frac{1}{8,6}$

CROSS-CHECK OF ROTATION TEST

$\alpha, \beta^\circ$



$C_l, C_m, C_n$



Plato 10

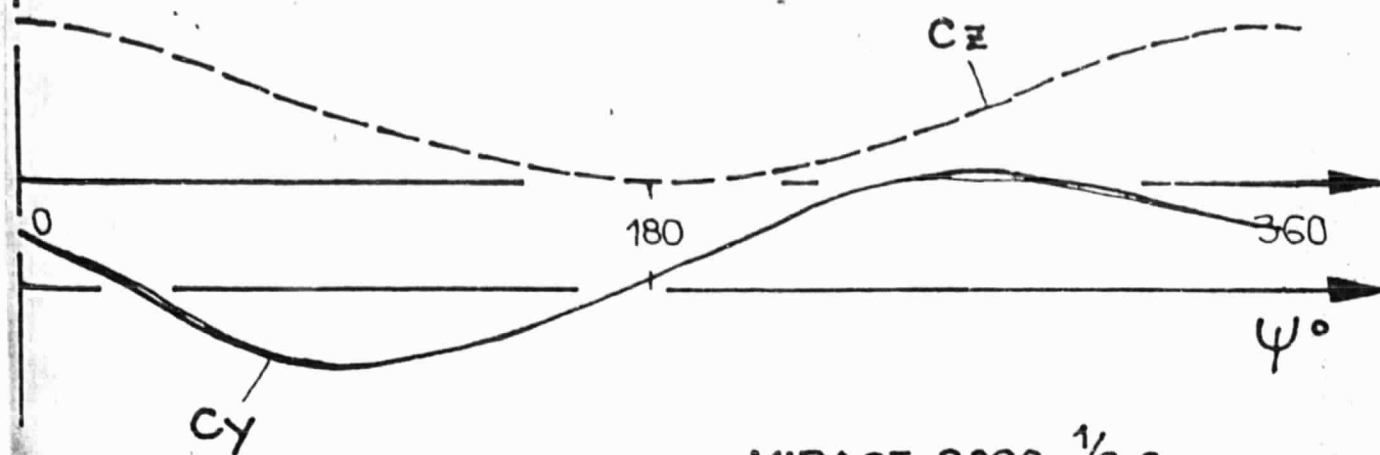
$\theta_2, \varphi = 0^\circ$

$\lambda = 15^\circ$

$\omega = 600^\circ/\text{s}$

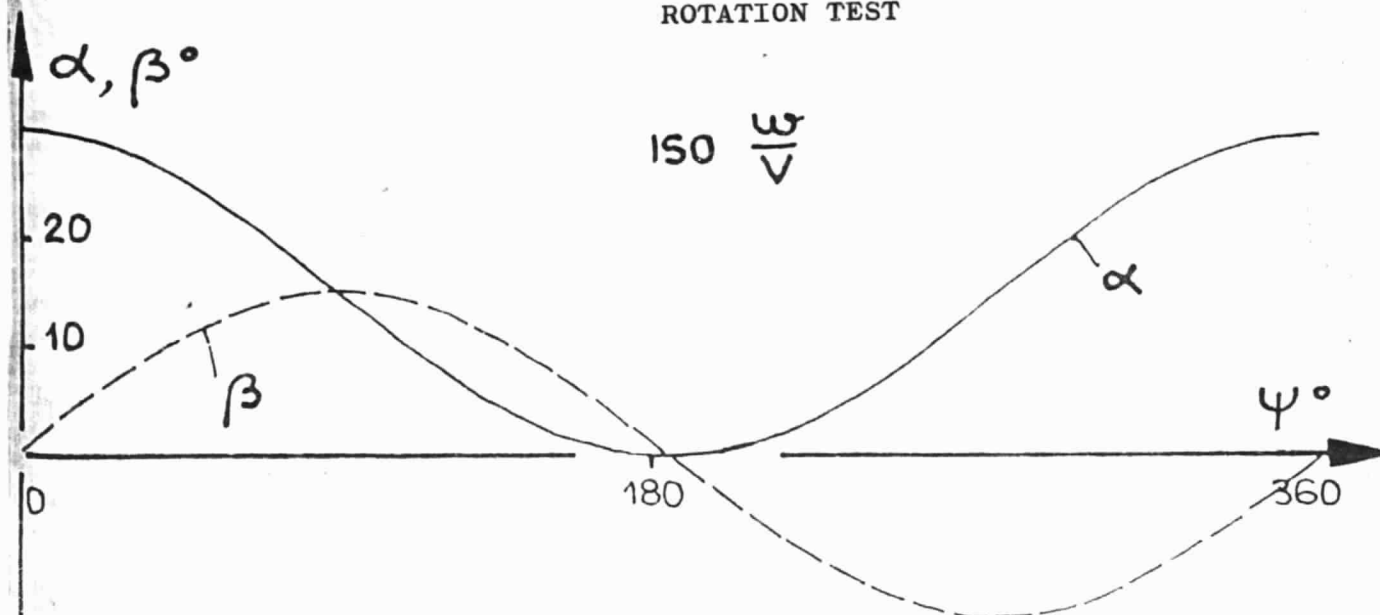
$V = 40 \text{ m/s}$

$C_y, C_z$  Lilienthal



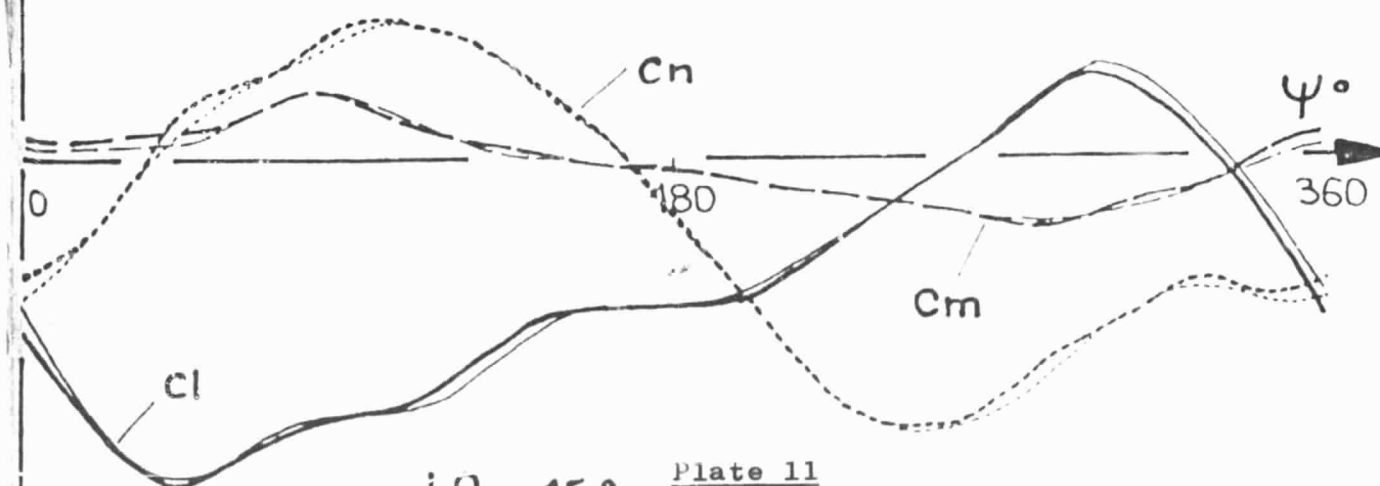
MIRAGE 2000  $1/8.6$

ROTATION TEST



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$C_l, C_m, C_n$  Lilienthal



$\theta_2 = 15^\circ$   
 $\varphi = 0^\circ$   
 $\lambda = 15^\circ$

Plate 11

$V = 40 \text{ m/s}, \omega = 600^\circ/\text{s}$

$V = 22.9 \text{ m/s}, \omega = 343^\circ/\text{s}$

$(\alpha, \beta)$

ENVELOPE OF THE 1ST INDUSTRIAL CAMPAIGN  
OF MARCH '79

$6 < \omega < 600\%$

